Mansoura University	Faculty of Engineering	Electronics and Comm. Dept.	4th Year, Optical Communication Systems	27/10/2015	Sheet #2

Q_1. Choose the correct answer

1-The values of the interatomic spacing for Si and Ge are ranging from
a) 3A -7A b)3µm-7µm c)3nm-7nm

2)Number of atoms in FCC is
a) one atom b)two atoms c) 4atoms

3)The wavelength emitted or absorbed for GaN having E_g=3.35ev is equal to
a)370nm b)270nm c)270µm

4) The bandgap energy for bulk structure is ..... that of quantum well structures made from the same material
a)greater than b)smaller than c)equal to

5)Each allowed state has been described by.....quantum numbers
a)Two b)three c)four

6)As the effective mass increases the density of states ……..
a)increases b)decreases c)doesn't change

7) As the effective mass increases the mobility of carriers…….
a)increases b)decreases c)doesn't change

8)As the frequency of collision increases, the carrier mobility……..
a)increases b)decreases c)doesn't change

9) The effective mass increases with the decrease in E for……
a)bulk structures b)quantum well structures c)Nano wire

10) If the effective mass is doubled, the density of state is……..... in **bulk material**
a)multiplied by2$\sqrt{2}$ b)doubled c) halved

11) If the effective mass is doubled, the density of state is ..... in **Quantum Well**
a)multiplied by2$\sqrt{2}$ b)doubled c)halved

12) As effective mass increases the curvature of E-K diagram.....
a)increases b)decreases c)doesn't change

13) The separation between two successive points along x-axis in K-space is equal to...
a)2π/Lx, Lx length of structure in x-direction b)π/Lx, Lx length of structure in x-direction c)Lx, , Lx length of structure in x-direction

Q_2. Estimate the following relations

a) Group velocity of electrons in solid

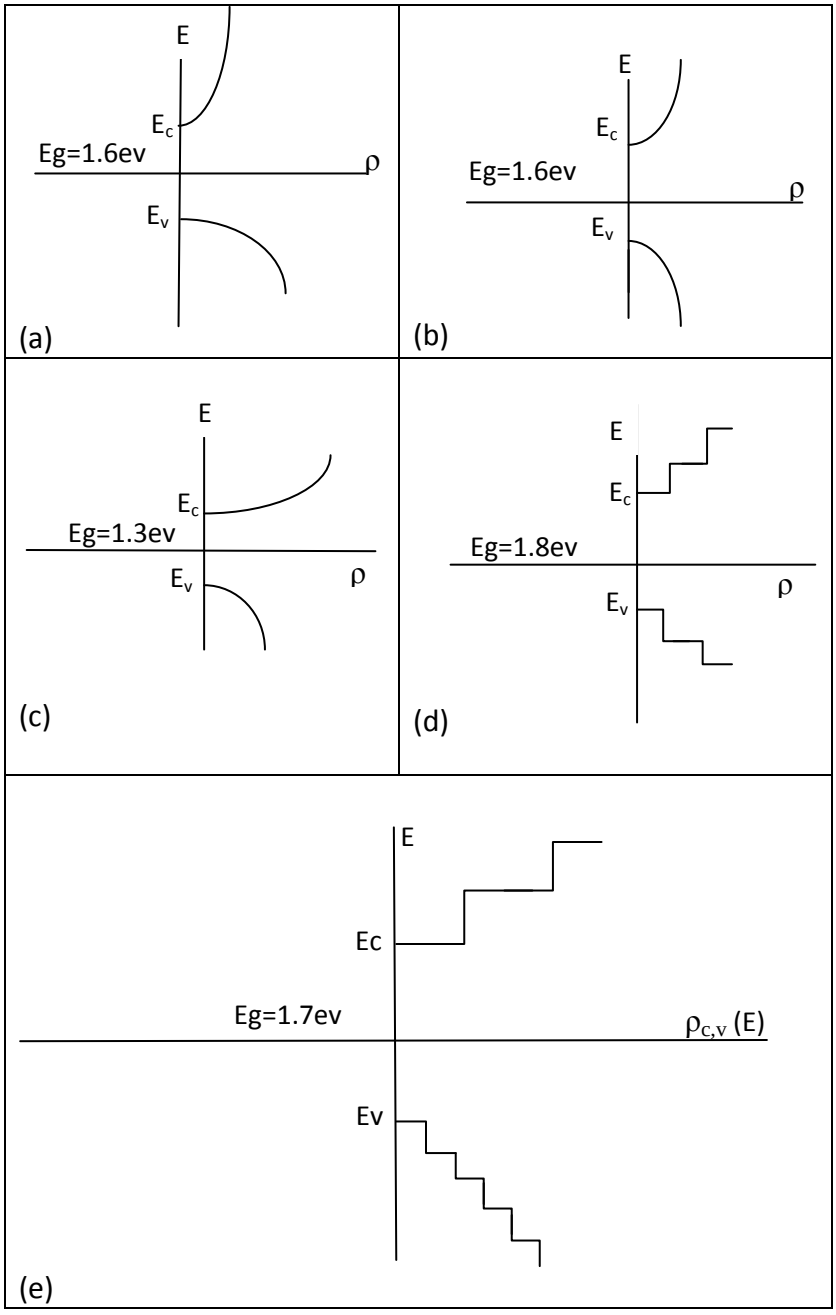
b) Effective mass exhibited by electrons in solids

c) Density of states $\rho_{c,v}(E)$ for 3D structures (bulk material)

d) Density of states $\rho_{c,v}$ (E) for 2D structures (Quantum Well)

e) Density of states $\rho_{c,v}$ (E) for 1D structures (Nano wire)

Q_3. Given the following curves for $\rho_{c,v}$ (E)



a) Determine the type of each structure based on its given density of states

b) Draw E-K diagram qualitatively for each material described by its density state.

c) Comment on the carriers motilities in each figure.

d) Estimate the values (E_{m1},E_{m2},E_{p1},E_{p2},E_{q1} and E_{q2})in curve (d) assuming structure dimensions are 1mm ×5mm ×8A and m_c=.067m_0, $m_0 = 9.1\times10^{-31}$ kg

e) Using the information given in (d) calculate the density of states per unit volume at

i)$E=E_c+E_{q1}/2$ ii) $E=E_c-E_{q1}/2$ iii) $E=E_c+1.5\ E_{q1}$ iv) $E=E_v+ 2E_{q1}$,

f) Using the information given in (d) calculate the number of allowed state within the whole structure for energy ranging from i) E_c to $E_c+E_{q1}/2$ ii) E_c+E_{q1} to E_c+2E_{q1}

g) Estimate the values of allowed states per unit volume for structure represented by curve (a) at energies (a)E_v-.1ev (b)E_c+0.1ev (c) E_c , assuming m_c=.08m_0 and m_v=0.28m_o

h) Estimate the total number of allowed states in the conduction band in structure represented by curve (a) assuming their dimensions are 1mm × 5mm × 3mm.

Q_4. Given

The cubic structure with 1mm side length and is made from materials with characteristics defined below.

E_2 (energy value in the conduction band) $=E_c+\frac{\hbar^2(K-6)^2}{2m_c}$ m_c=0.98m_0

E_1 (energy value in the valence band) $=E_v-\frac{\hbar^2K^2}{2m_v}$ m_v=0.49m_0 and Eg=1.1ev

a) Draw qualitatively the following curves:

i- E-K diagram and determine whether the considered material has direct or indirect bandgap and what is the indication of this classification?

ii- Density of states curves for conduction and valence bands and calculate no of allowed states in the conduction band ranging from Ec to Ec+0.1

b) Repeat the solution of (a) when the dimensions of structure doubled

c) Repeat the solution of (a) when the dimensions of the structure changed to be 1mm×1mm× 10A

d) Repeat the solution of (a) when the values of m_c changed to 0.08 m_0 and m_v=0.28 m_0